a/PRTS

DaimlerChrysler AG
Stuttgart

Electrically heatable glow plug or glow rod for internal combustion engines

The invention is based on an electrically heatable glow plug or a glow rod for internal combustion engines according to the precharacterizing clause of Claim 1, such as emerges as known, for example, from EP 450 185 B1.

Glow plugs are used in the combustion chamber in diesel engines for preheating purposes during cold starting or - in the form of a glow rod in the induction passage - for preheating the induction air. The glow plug or the glow rod comprises a corrosion-free, metallic casing, a heating and regulating coil and an electrically insulating, compacted powder filling. In the heating region, the heating and regulating coil consists of ferritic steel onto which a pure nickel wire is welded as a regulating resistor.

During operation, the material of the heating coil is subject to a thermal and chemical influence which may adversely affect the service life of the glow plug. These influences at least constitute essential parameters with regard to the service life of the glow plug. On account of the high operating temperatures of the heating coil and, as before, there still being oxygen in the compacted powder filling, the heating coil is subject to creeping corrosion. In specific terms, this may firstly be intercrystalline corrosion which is furthered by the growth of crystals and the tendency to form large grains in ferritic heat conductors. Secondly, at high

temperatures corrosion may occur on the free surface of the heating coil and may therefore lead to weakening of the heating-wire cross section.

Magnesium oxide is generally used as the powder filling. In order to minimize the atmospheric oxygen contained in the pores of the powder filling, the powder is very intensively compacted by the filled metal casing being upset from the outside by a concentrically acting striking tool and thereby being reduced in diameter. The powder filling is compacted particularly intensively in the region of the heating-rod tip by the metal casing being upset conically there.

The object of the invention is to improve a glow plug based on the generic type in respect of a longer service life for the heating coil.

Taking the glow plug based on the generic type as the starting point, this object is achieved according to the invention by the characterizing features of Claim 1. This is because it has been found that, during the compaction of the powder filling, the radial upsetting of the casing pipe also causes severe mechanical stress on the wire of the heating coil and on the wire of the regulating coil and in the process causes said wire to be unintentionally damaged at the outset, for example due to notches, depressions or the like, i.e. causes its cross section to be constricted locally. On account of the increase in hardness of the coil on its surface, in particular by nitriding, the coil is able to withstand the mechanical stress during compaction of the powder filling without being significantly damaged at the outset.

Expedient refinements of the invention can be gathered

from the subclaims; the invention is also explained in more detail below with reference to an exemplary embodiment which is illustrated in the drawing, in which:

Fig. 1 shows a longitudinal section through a glow plug,

Fig. 2 shows an enlarged illustration of the detail II from Figure 1, and

Fig. 3 shows a cross section through a conventional glow plug in the region of the detail II where the surface of the coil has been damaged at the outset by the mechanical stress during compaction of the powder filling.

In diesel engines, glow plugs are used in the combustion chamber for preheating during cold starting or - as a rod-shaped flame glow plug or flame system in the air inlet passage - for preheating the air. The exemplary embodiment of a glow plug which is illustrated in Figure 1 has a glow pipe 5 which is secured in a plug body 1 and is connected thereto in an electrically conductive manner. The casing of the glow pipe generally consists of a nickel-rich iron alloy or of a corrosion-free alloy based on nickel, for example Inconel 601, and is as a rule electrically connected as an earth pole, i.e. negatively. This electric earth connection comes about via the screw-in thread 7 and/or by the cone 7a at the lower end of the plug body 1.

A heating coil 8 having a regulating coil 9 which is welded to it via a connecting weld 11, and an electrically insulating, compacted powder filling 10 are arranged in the glow pipe. This powder filling has a

number of functions, particularly in the compacted state: first of all, it ensures that the heating coil (8) and regulating coil (9) are accommodated and fixed in position within the glow pipe and are held in an electrically insulated manner. The compacted powder means that the heat produced in the heating coil 8 is inevitably passed on as readily as possible to the casing of the glow pipe. In addition, the compressing of the powder is intended to eliminate to the greatest possible extent any air pockets, in particular a certain amount of residual oxygen. This requires a particularly intensive compaction of the powder, particularly in the region of the heating coil 8.

In the heating region (heating coil 8), the heating and regulating coil 8, 9 consists of a ferritic steel, for example of an iron-chromium-aluminium alloy having 17 to 22% chromium and 3 to 7% aluminium; a frequently used alloy is Kantal AF CrAl225. A coiled wire (regulating coil 9) made of pure nickel, which has the function of a regulating resistor, is welded (connecting weld 11) onto a heating coil of this type. The heating coil 8 is connected to the glow pipe in the tip of the glow pipe via a sealing weld 12.

The other end of the regulating coil 9 is connected to a connecting bolt 2 which is embedded in an insulating washer 4, is electrically insulated and is led out of the plug body 1 in a sealed manner via a seal 6. The connecting bolt is connected via a nut 3, which brings a cable lug securely into contact with the connecting bolt, to the plus pole of a current source. In addition, the connecting bolt 2 is sealed at the upper, open end of the glow pipe by a soft, insulating seal 6' which is intended to reliably prevent atmospheric oxygen from penetrating

into the compressed powder filling.

In general, magnesium oxide is used as the powder filling 10. In order to compact the powder filling - as described, the filled glow pipe is upset radially from the outside by a concentrically acting striking tool and is thereby reduced in diameter, it also being possible for a conical profile to be achieved. The powder filling is particularly intensively compacted especially in the region of the glow-pipe tip by the metal casing there being upset radially in a particularly severe manner.

On account of the intense compaction of the powder filling, the entire coil 8, 9, but in particular the heating coil 8, is severely stressed mechanically. During the radial upsetting of the glow pipe 5 not only is its casing plastically deformed, but so too are the coils 8 and 9 mounted in it. The compacting and compacted powder filling 10 also transmits actions of force from the striking tools acting from the outside isostatically to the turns of the heating and regulating coils 8 and 9 and reduces the diameters thereof to an appropriate extent during this process. Since, however, the powder filling is not completely homogeneous, but is subject to certain unevennesses, the forces exerted on the coils via the powder filling differ in size locally in accordance with the dispersion of the powder density.

In the case of untreated coils, this leads to a locally differing plastic upsetting of the coils. The differing upsetting for its part causes a stochastically pitted surface of the coils 8', as is shown in Figure 3 using the example of a conventional design of a glow plug together with an untreated coil 8'. Even when new, this coil has a pitted surface 15 after compaction of the

powder. According to the findings of the invention, a certain amount of damage from the outset is to be found in this surface pitting. This is because stochastic pitting of this type may result in local cross-sectional constrictions of the conductor cross section of the coil. This local cross-sectional constriction in turn leads to a local increase in the electrical resistance and therefore to a locally more severe heating of the coil during operation. This means that the thermal and chemical ageing processes progress more rapidly at this point, because of the higher temperature level, than at other points. Such a constriction, which is initially only small and is caused by pitting, of the conductor cross section of the coil can therefore be a determining factor in the service life, i.e. can be a factor shortening the service life.

The invention intends to increase the service life of the coils, in particular the heating coil 8 which is particularly severely stressed mechanically during compaction and is also particularly severely stressed thermally during operation. In order to increase the service life, according to the invention the electrically conductive coils 8, 9 but at least the heating coil 8 which is particularly at risk, are surface-hardened. In specific terms, a diffusion treatment, such as nitriding, is advantageously recommended, said treatment leading, through the formation of nitride in the diffusion zone, to an increase in the hardness, and as a result of the diffusion processes produces a gradual transition from the hardened edge zone to the soft core. This diffusion zone 13 of the coils 8, 9 expediently has a depth t of approximately 5 to 10 μm.

Although the coils are hardened merely in an edge layer

13 near to the surface, they nonetheless remain plastically deformable as a whole. On the other hand, pronounced pitting of the wire surface during radial compaction of the powder filling is avoided by the hardening of the edge layer. Even after the compaction of the powder filling, the coils have a smooth surface 14. As a result, mechanical damage at the outset to the conductor wire is avoided. The consequence is a longer service-life expectation for the conductor and therefore for the entire glow plug.